

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-302463

(43)Date of publication of application : 24.10.2003

(51)Int.Cl.

G01S 13/10  
G01S 7/292  
// G08G 1/16

(21)Application number : 2002-109532

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(22)Date of filing : 11.04.2002

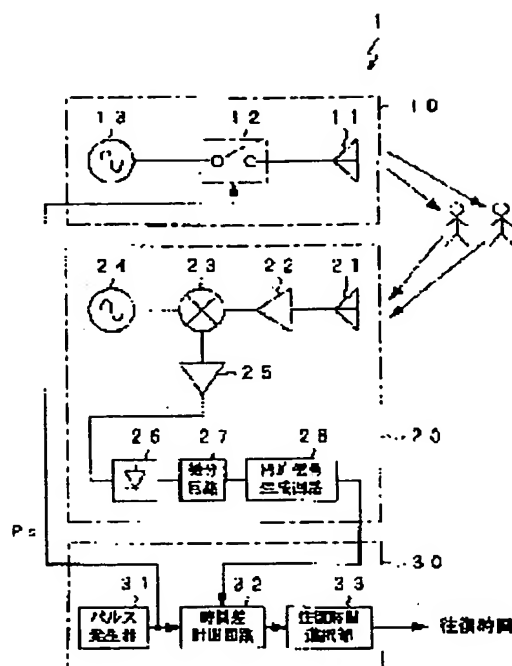
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## (54) RADAR APPARATUS

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To improve the distance resolution without increasing the occupied bandwidth of a radar wave in a radar apparatus for detecting the target distance by transmission/reception of the pulsing radar wave.

**SOLUTION:** In a reception part 20, a demodulation signal acquired by demodulating a reception signal of the radar wave is differentiated by a differentiating circuit 27, to thereby generate a differentiated signal for showing a variable point of a signal level of the demodulation signal, and a trigger signal generation circuit 28 generates a trigger signal for inverting the signal level at each timing of the variable point, based on the differentiated signal. A time difference measuring circuit 32 in a control part 30 measures the times from a rising edge of a transmission pulse signal Ps to each edge of the trigger signal, and a round-trip time selection part 33 combines measurement results wherein the difference of both times is nearly equal to the pulse width of the transmission pulse signal Ps, and extracts a result having smaller value between the pair of measurement results as time data for showing the round-trip time.



## LEGAL STATUS

[Date of request for examination] 08.06.2004

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision]

of rejection]

[Date of requesting appeal against examiner's  
decision of rejection]

[Date of extinction of right]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the radar installation which transmits and receives a pulse-like radar wave and detects a target.

[0002]

[Description of the Prior Art] The radar installation (a "pulse radar" is called below) of a pulse method is known as one of the radar installations which transmits and receives a radar wave and detects a target conventionally.

[0003] Drawing 3 is a block diagram showing the general configuration of a pulse radar 100 here. The pulse radar is constituted by the receive section 120 which turns into the transmitting section 110 which consists of the transmitting antenna 11, a switch 12, and an oscillator 13 from a receiving antenna 21, the low noise amplifier 22, a mixer 23, the local oscillator 24, IF amplifier 25, a wave detector 26, and a comparator 29, and the control section 130 which consists of a pulse generator 31 and a time difference measurement circuit 32 as shown in drawing 3.

[0004] And a pulse-like radar wave is made to transmit to the transmitting antenna 11 in the transmitting section 110 by a switch's 12 operating according to the transmitted pulse signal Ps which the pulse generator 31 of a control section 130 generated, and supplying the RF signal with which the oscillator 13 generated only the period of the pulse width of the transmitted pulse signal Ps to the transmitting antenna 11.

[0005] Moreover, in a receive section 120, a down convert is carried out at the signal (IF signal) of an intermediate frequency band by the low noise amplifier's 22 amplifying the input signal of the radar wave which the receiving antenna 21 received, and mixing this with the local signal and mixer 23 from the local oscillator 24. After amplifying that IF signal with IF amplifier 25, receiving pulse signal Pr is generated because a wave detector 26 gets over by performing envelope detection and shapes in waveform further this signal to which it restored with a comparator 29.

[0006] Moreover, in a control section 130, a pulse generator 31 also supplies the time difference measurement circuit 32, while supplying the transmitted pulse signal Ps to the transmitting section 110, and the time difference measurement circuit 32 is measured as both-way time amount which took the time difference of the transmitted pulse signal Ps from a pulse generator 31, and receiving pulse signal Pr from a receive section 120 for a radar wave to go and come back to the distance to a target.

[0007] And the distance R to a target is found from the measurement result t of this both-way time amount using the degree type (1).

$$R=C-(t-t_0)/2 \quad (1)$$

However, at the velocity of light, C is  $C=3 \times 10^8$  m/s and  $t_0$  is signal delay in a circuit.

[0008]

[Problem(s) to be Solved by the Invention] By the way, since it is necessary to perform a collision judgement to use a pulse radar as for example, a mounted radar for a circumference monitor, high distance resolution (at least dozens of cm) is needed. And in a pulse radar, distance resolution can be raised so that pulse width of a radar wave (transmitted pulse signal Ps) is shortened, but the occupancy bandwidth of a radar wave increases, so that pulse width is

shortened on the other hand. For example, if it is going to obtain the distance resolution of about 10cm, the occupancy bandwidth will amount also to several GHz.

[0009] On the other hand, by the specification (ARIB STD-T73) about the radio equipment for specified low power radio station mobile detection sensors, the band conditions in the 24GHz band applied to such a mounted radar are 76MHz or less. That is, when it was going to fulfill this band condition, distance resolution became several m order and there was a problem that it could not be used in the application which needs high resolution, such as a mounted radar.

[0010] That is, when the range difference to each target is shorter than distance resolution, as two targets exist, and it is shown in drawing 4, the reflected wave from these targets is received with a time interval shorter than the pulse width of the transmitted pulse signal Ps, and the recovery signal which comes to get over the input signal with a wave detector 26 becomes what the signal from each target overlapped mutually. And if this signal is shaped in waveform with a comparator 29, single large receiving pulse signal Pr of pulse width is generated, the receiving timing of the reflected wave which was overdue and received disappears, and distance of the target which became that reflective origin cannot be detected.

[0011] This invention aims at raising distance resolution, without increasing the occupancy bandwidth of a radar wave in the radar installation which detects the distance of a target by transmitting and receiving a pulse-like radar wave, in order to solve the above-mentioned trouble.

[0012]

[Means for Solving the Problem] In the radar installation according to claim 1 which is invention for attaining the above-mentioned purpose According to the inputted transmitted pulse signal, transmit a pulse-like radar wave, and if a transceiver means generates the recovery signal based on the radar wave which received a change check appearance means -- the changing point of the signal level of the recovery signal -- detecting -- a time check -- a means measures the time amount from the transmit timing of the radar wave by the transmitted pulse signal to the changing point detected with the change check appearance means. And a time data extract means extracts the time data showing the both-way time amount of the radar wave to [ out of the measurement result ] a target.

[0013] That is, the recovery signal based on two radar waves received at spacing shorter than the pulse width of a transmitted pulse signal Have the wave which compounded two pulses and a signal starts to the receiving timing of the radar wave which received previously. A signal falls to the disappearance timing of the radar wave which signal level changed again to the disappearance timing of the radar wave which signal level changed and received previously after that to the receiving timing of the radar wave which received later, and received later.

[0014] since [ thus, ] the receiving timing of both the radar wave is contained in the changing point that the signal level of a recovery signal changes -- a time check -- it becomes possible by making it measure to the timing of these changing points for a means to detect the distance of two or more targets in the range difference below distance resolution separately.

[0015] Therefore, substantial distance resolution can be raised, without according to the radar installation of this invention, shortening pulse width of a radar wave and increasing the occupancy bandwidth of a radar wave. In addition, what is necessary is just to constitute a time data extract means so that the one where a value is smaller may be extracted as time data among both the measurement results combined, for example combining the measurement result according to claim 2 only whose pulse width of a transmitted pulse signal has time difference like.

[0016] That is, the isolated changing point without the partner from whom a recovery signal becomes a pair since a changing point appears in the rising edge and falling edge of each pulse is considered to be a noise, and can raise the dependability of time data by removing this.

[0017] Moreover, as a change check appearance means, a differential circuit can be used, for example like claim 4 publication.

[0018]

[Embodiment of the Invention] The operation gestalt of this invention is explained with a drawing below. Drawing 1 is the block diagram showing the configuration of the mounted radar for a

circumference monitor (only henceforth a "radar installation") by which this invention was applied. In addition, conventionally which is shown in drawing 3, since the configuration only differs from equipment in part, the radar installation of this operation gestalt attaches the same sign about the same component, omits explanation, and explains it focusing on the part in which a configuration carries out difference.

[0019] The radar installation 1 of this operation gestalt is constituted by the receive section 20 which consists of the transmitting section 10 which consists of the transmitting antenna 11, a switch 12, and an oscillator 13, a receiving antenna 21 and the low noise amplifier 22, a mixer 23, the local oscillator 24, IF amplifier 25, a wave detector 26, a differential circuit 27, and a trigger signal generation circuit 28, and the control section 30 which consists of a pulse generator 31, a time difference measurement circuit 32, and the both-way time amount selection section 33 as shown in drawing 1.

[0020] That is, conventionally, as compared with equipment 100, in a receive section 20, a differential circuit 27 and the trigger signal generation circuit 28 are formed instead of a comparator 29, and the both-way time amount selection section 33 is added by the control section 30. And as shown in drawing 2 R> 2, when a differential circuit 27 differentiates the recovery signal to which it restored with the wave detector 26, the signal level of a recovery signal generates the differential signal showing the changing point of changing in instant, and the trigger signal generation circuit 28 generates the trigger signal which signal level reverses for every timing of the changing point which this differential signal expresses in a receive section 20.

[0021] It is based on this trigger signal. In the time difference measurement circuit 32 of a control section 30 Each edge which the signal level of a trigger signal reverses from the rising edge of the transmitted pulse signal Ps The time amount (T1 - T four) to (namely, the changing point of a recovery signal) is measured, respectively, and it is based on the measurement result. The both-way time amount selection section 33 Each measurement result is combined by those from which both time difference becomes almost the same as the pulse width of the transmitted pulse signal Ps. It extracts as time data showing the both-way time amount which took the one where a value is smaller for a radar wave to go and come back to the distance to a target among the measuring times of the combined pair.

[0022] That is, in drawing 2, T1, T3 and T2, and T four will be put together, among those T1 and T2 with a small value will be extracted as time data. As explained above, in the radar installation 1 of this operation gestalt, the recovery signal which restores to the input signal (IF signal) of a radar wave, and becomes is not shaped in waveform simply, but the changing point that the signal level of a recovery signal changes is extracted, it is the timing of this changing point and time amount is made to be measured. That is, when two or more radar waves overlap and are received, the timing (namely, receiving timing of the radar wave which received later) from which the lap of a radar wave began, and the timing (namely, timing to which the radar wave which received previously disappeared) which the lap finished are also detected as this changing point.

[0023] Thus, according to the radar installation 1 of this operation gestalt, even if two or more radar waves overlap and are received, the receiving timing of each radar wave can be extracted according to an individual, and substantial distance resolution can be raised, without shortening pulse width of a radar wave (transmitted pulse signal Ps), since it is possible to perform timing measurement about each.

[0024] And in the radar installation 1 of this operation gestalt, since the isolated timing without the partner who combines by combining the measurement result which has the time difference for pulse width of the transmitted pulse signal Ps is removed as a noise, the dependability of time data can be raised.

[0025] In addition, in this operation gestalt, although the trigger signal generation circuit 28 is generating the trigger signal which signal level reverses to the timing of a differential signal, it is good also considering the signal generated by rectifying and shaping a differential signal in waveform, for example as shown in drawing 2 (f) as a trigger signal. However, in this case, it is necessary to constitute the time difference measurement circuit 32 so that only the rising edge of a trigger signal may be used for time difference measurement.

[0026] moreover, the above-mentioned operation gestalt -- setting -- the configuration to the receiving antenna 21 of the transmitting section 10 and a receive section 20 -- a wave detector 26 -- a transceiver means, a differential circuit 27, and the trigger signal generation circuit 28 -- a change check appearance means and the time difference measurement circuit 32 -- a time check -- a means and the both-way time amount selection section 33 are equivalent to a time data extract means.

[Translation done.]

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CLAIMS

[Claim(s)]

[Claim 1] If a pulse-like radar wave is transmitted by the input of a transmitted pulse signal and a radar wave is received A transceiver means to generate the recovery signal which comes to get over the input signal, and a change check appearance means to detect the changing point of the signal level of the recovery signal which this transceiver means generates, the time check which measures the time amount from the transmit timing of the radar wave by said transmitted pulse signal to each changing point which said change check appearance means detected -- with a means this -- a time check -- the radar installation characterized by having a time data extract means to extract the time data showing the both-way time amount of the radar wave to [ out of the measurement result in a means ] a target.

[Claim 2] said time data extract means -- said time check -- the radar installation according to claim 1 characterized by extracting the one where a value is smaller as said time data among combination and the measurement result of the pair put together by those to which only the pulse width of said transmitted pulse signal has time difference for the measurement result in a means.

[Claim 3] Said change check appearance means is a radar installation according to claim 1. or 2 characterized by consisting of a differential circuit.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is a block diagram showing the configuration of the radar installation of an operation gestalt.

[Drawing 2] It is a timing chart for explaining actuation of the principal part.

[Drawing 3] It is the block diagram which expresses the configuration of equipment conventionally.

[Drawing 4] It is a timing chart for explaining the trouble of equipment conventionally.

[Description of Notations]

1 -- radar installation, the 10 -- transmitting section, and 11 -- a transmitting antenna, 12 -- switch, 13 -- oscillator, and 20 -- a receive section, 21 -- receiving antenna, 22 -- low noise amplifier, and 23 -- a mixer, a 24 -- local oscillator, 25 -- IF amplifier, and 26 -- a wave detector, 27 -- differential circuit, 28 -- trigger signal generation circuit, and 28 -- a waveform shaping circuit, 29 -- comparator, 30 -- control section, and 31 -- a pulse generator, 32 -- time difference measurement circuit and 33 -- round trip time amount selection section

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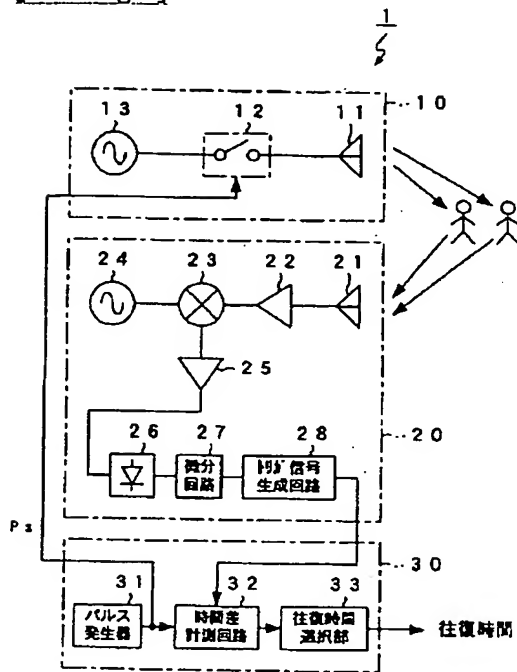
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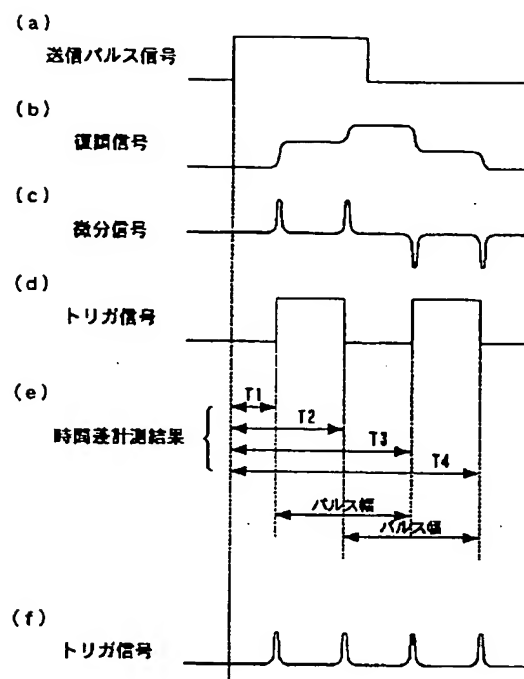
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## DRAWINGS

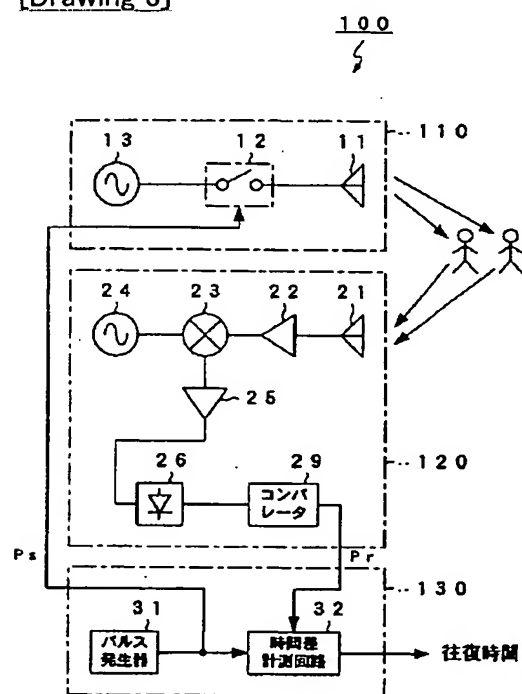
[Drawing 1]



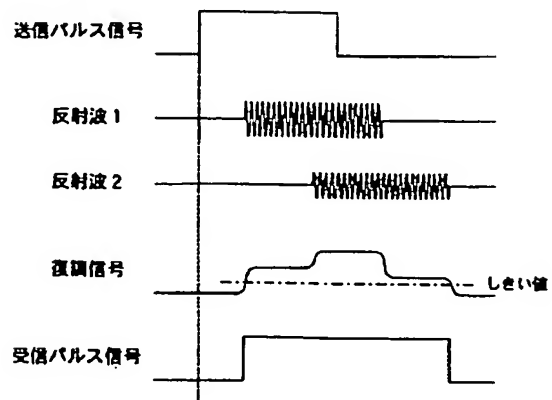
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]